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(54) Name of the invention: Substrate Plate Used in Plasma Display devices and Its Manufacturing Method

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(54) [Name of the invention]

Substrate Plate Used in Plasma Display Devices and Its Manufacturing Method

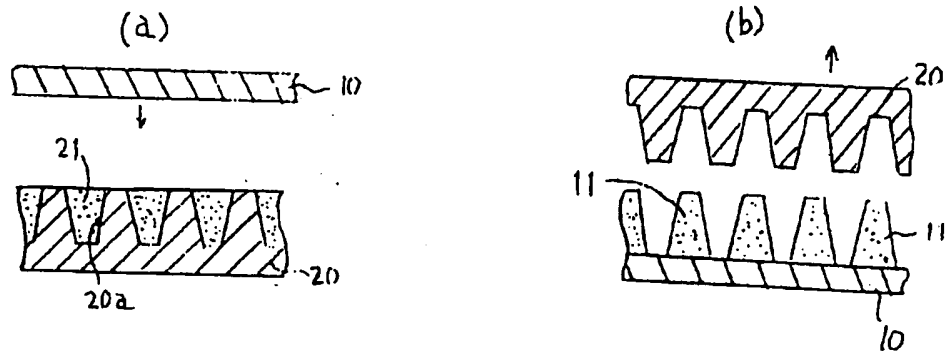
(57) [Summary]

[Topic]

The topic of the present invention is the a substrate plate that is used in plasma display devices and the easy formation of the microscopic shape of the barrier 11, at a high precision.

[Solution measures]

A molded material that is obtained as a mixed material formed from ceramics or glass powder material and a binder material, is filled inside the molding die 20, and the back surface plate 10, that is formed from ceramics or glass, are bonded and unified as one body, and the structure of a substrate plate used in plasma display devices, is formed.



**[Range of the claims of the invention]**

**[Claim 1]**

A substrate plate used in plasma display devices that is formed as a molded material, that is obtained as a mixed material formed from ceramics or glass powder material and a binder material, is filled inside the molding die 20, and the back surface plate 10, that is formed from ceramics or glass, are bonded and unified as one body.

**[Claim 2]**

Substrate plate used in plasma display devices, characterized by the fact that on the back surface plate, that is formed from ceramics or glass, the structure of display cells, is formed, that is formed from ceramics or glass, and that is equipped with numerous barriers, and the cell dimensions of the cell part of the above described display cell 1000, was measured in 45 columns, and at that time, the largest difference in the measured values was 0.05 mm or less.

**[Claim 3]**

Manufacturing method for the preparation of substrate plate used in plasma display devices, that consists of the following technological processes: a mixed material obtained from ceramics or glass powder material and a solvent media and a binder that is formed from organic additive materials, is filled inside the molding die, that has an indented part that is used for the barriers, and after that, this mixed material is bonded on the back surface plate that is formed from ceramics or glass, and it is formed and unified as one body.

**[Detailed explanation of the invention]**

[0001]

**[Technological sphere pertinent to the present invention]**

The present invention is an invention about a substrate plate that is used in plasma display devices, that in turn are used in high precision and also inexpensive thin shape large image surface using color display devices, etc., and its manufacturing method.

[0002]

[Previous technology]

In the case of the plasma display devices, that can be used in thin shape large image surface using color display devices, etc., they have a structure that is formed as in the spaces that are surrounded by barriers that are called fine display cells, opposing electrodes are provided, and in the above described spaces a rare gas, etc., discharge capable gas is introduced and sealed, and by the electrical discharge in the space between the opposing electrodes, plasma is generated, and by the above described plasma, a fluorescent light material is generated, and this is an item that is used as the light generating element of the image surface.

[0003]

A detailed structure is shown according to the presented in Figure 3, and according to that, on one surface of the back surface plate 10, a large number of barriers 11, are formed, and each space between the barriers 11, is used as the cells 13, and on the bottom surface of these cells 13, the electrodes 12, are provided, and this is used as the substrate plate 1. Relative to this substrate plate 1, on the inner wall surface 13 a of the cells 13, a fluorescent light material is coated, and on the other hand, the equipped with the electrodes 15 front plate 14, is bonded on the top of the barrier 11 of the substrate plate 1, and in the cells 13, gas is introduced and sealed and by that it is possible to form the structure of the plasma display device.

[0004]

However, at the time of the manufacturing of the substrate plate 1, that is used in the above described plasma display devices, in advance on the back surface plate 10, a large number of electrodes 12, is formed, and after that, in the space between each of the electrodes 12, the barriers 11, are formed. However, as the manufacturing method for the formation of these barriers 11, the printing laminated layer method and the blasting method, etc., have been known.

[0005]

Regarding the printing laminated layer method, by using a paste of the material that is forming the barriers 11, and by employing the thick layer printing method, on the top of the back surface plate 10, the predetermined pattern barriers 11, are printed and formed, and by that, the thickness that can be formed by a one time printing is in the range of approximately 10 ~ 15 microns, and because of that, it is a case where the formation of the barriers 11 is conducted as the printing and the drying are repeated, so that the necessary height, that is in the range of approximately 100 ~ 200 microns, is obtained (as illustrated according to the reported in the Japanese Patent

Application Laid Open Number Hei-Sei 2-213020).

[0006]

Also, regarding the blasting method, it is a method where over the whole surface of the back surface plate 10, a glass layer with the desired thickness, is formed, and on the front surface of that, a resistor mask with the shape of the barriers 11, is formed, and by using sand blasting, the glass layer of the parts outside the barriers 11, is removed (as illustrated according to the reported in the Japanese Patent Application Laid Open Number Hei-Sei 4-259728).

[0007]

**[Problems solved by the present invention]**

However, in the case of the above described printing laminated layer method, in order to form the barriers 11 with the predetermined height, it is necessary that several printing - drying technological processes are repeated, and the number of the technological processes becomes extremely large, and moreover, for each of the laminated layers it is necessary to have a printing with good precision, and because of that, the yield rate becomes extremely poor. Then, because of the position deviation at the time of the printing, it is easy to change the shape of the barrier 11, and also, because of the elongation of the printing plate etc., as the precision of the dimensions of the display cells that are formed by the barriers 11, the largest difference of the measurement values at the time when the dimension of the 1000 cell part, was measured in 45 columns, was 0.35 mm, and it was a method that did not satisfy the requirements for a high resolution.

[0008]

Also, in the case of the above described blasting method, for the formation of the mask a photo resistor is used, and after that, a sand blasting is conducted, and because of that, the technological process is complex, and not only that, but also, the formation of the barriers 11 at a high degree of precision was difficult. Then, in the case when the abrasive agent that is employed in the blasting technological process, is recovered and repeatedly used, because of the deterioration and the wear of the abrasive agent, the grinding force is decreased or there is a change with the passing of the time, and a stable mass production was difficult. On the other hand, in the case when the abrasive agent is used without recovery, the cost of the abrasive agent becomes high, and in this case also, the large mass production was difficult.

[0009]

Consequently, according to any of the above described manufacturing methods, the inexpensive and precision manufacturing of the substrate plate 1, that is used in a

large form factor display devices, and that has a fine pitch, by a simple technological process, was difficult.

[0010]

**[Goal of the present invention]**

The present invention has taken into consideration the above described problem points, and its goal is to suggest a substrate plate, that is used in plasma display devices, and its manufacturing method, where the substrate plate that is used in the plasma display devices is manufactured by a one time simple molding technological process, and it is manufactured at a good yield rate, and together with that, high precision barriers that do not have a change in shape and that have a smooth front surface, are obtained at the predetermined height, and a large image surface of at least 40 inches or higher, can be easily obtained in practice, and a high resolution degree where the pitch of the display cells is less than 0.25 mm, can be practically realized.

[0011]

**[Measures in order to solve the problem]**

Regarding the substrate plate used in plasma display devices, according to the present invention, it is a substrate plate where ceramics or glass powder material and a binder material, is filled inside the molding die 20, and the back surface plate 10, that is formed from ceramics or glass, are bonded and unified as one body.

[0012]

Also, regarding the substrate plate used in plasma display devices, according to the present invention, it is characterized by the fact that on the back surface plate, that is formed from ceramics or glass, the structure of display cells, is formed, that is formed from ceramics or glass, and that is equipped with numerous barriers, and the cell dimensions of the cell part of the above described display cell 1000, was measured in 45 columns, and at that time, the largest difference in the measured values was 0.05 mm or less.

[0013]

And then, the manufacturing method for the preparation of substrate plate used in plasma display devices, is characterized by the fact that it is a method that consists of the following technological processes: a mixed material obtained from ceramics or glass powder material and a solvent media and a binder that is formed from organic additive materials, is filled inside the molding die, that has an indented part that is

used for the barriers, and after that, this mixed material is bonded on the back surface plate that is formed from ceramics or glass, and it is formed and unified as one body.

[0014]

[Effect]

According to the substrate plate used in plasma display plates and its manufacturing method, according to the present invention, a mixed material consisting of ceramics or glass powder material and a binder, is filled in the molding die, and the barrier molded material, is obtained, and because of that, due to the fact that the state of the front surface of the barriers is good, and also, because the dimensional precision of the molding die is reflected in the molded material as it is, because of all of these, it is possible to easily manufacture a large scale substrate plate by a one time molding technological process.

[0015]

**[Conditions of the practical implementation of the present invention]**

In the description here below, the practical implementation of the present invention is explained.

[0016]

As it is shown according to Figure 1, the substrate plate 1, that is used in plasma display devices, is provided with the complex number of barriers 11, that are formed from ceramics or glass, on one surface of the back surface plate 11, that is formed from ceramics or glass, and in the space between each barrier 11, the cells 13 are formed.

[0017]

Then, at the bottom surface of these cells 13, the electrodes 12, are provided, and on the inner wall surface 13 a of the cells 13, a fluorescent light material is coated, and after that, as it is shown according to Figure 3, by using the front surface plate 14, that is provided with the electrodes 15, the upper edges of the barriers 11, are covered, and in the cells 13, gas is introduced and sealed off, and by that it is possible to form the structure of the plasma display device. Then, by the conducting of an electrical discharge in the space between the electrodes 12 and 15, it is possible to generate light in the fluorescent light material, that has been coated on the inner wall surface 13 a of the cells 13.

[0018]

After that, the manufacturing method for the preparation of the above described substrate plate 1, is explained.

[0019]

First, as it is shown in Figure 2 (a), the molding die 20, that has the indented part 20 a, that coincides with the shape of the barriers 11, is prepared. And in the indented part 20 a of this molding die 20, as the material forming the barriers 11, the mixed material 21, that is formed from ceramics or glass powder material and a solvent and organic additive binder material, is filled.

[0020]

On the other hand, the back surface plate 10, that is formed from ceramics or glass, is separately prepared. And on this back surface plate 10, the molded material from the above described mixed material 21, is bonded and formed as one body, and the barriers 11, are formed. However, in more details, it is manufactured according to the described here below.

[0021]

First, on the surface of the mixed material 21, that is filled into the above described molding die 20, the back surface plate 10, is pressed appropriately and it is pressure adhered, and the mixed material 21 is reaction cured or dried and fixed. After that, as it is shown in Figure 2 (b), where the top and the bottom are reversed, the molding die 20 is subjected to a mold release, and by that on the top of the back surface plate 10, the barriers 11, that are formed from the molded material consisting of the mixed material 21, are copied. And finally, the whole surface is treated so that the binder is removed, and after that, it is simultaneously annealed and unified as one body, and by that, it is possible to manufacture the substrate plate 1, that is used in the plasma display device shown according to Figure 1.

[0022]

Also, as another method, there is the method where the mixed material 21, that is filled into the molding die 20, is reaction cured or dried, and it is solidified, and after that, it is die released from the molding die, and the molded body formed from the mixed material 21, is adhered onto the back surface plate 10. And then, finally, the whole surface is treated for removing the binder material, and after that, it is simultaneously annealed and unified as one body, and by that also, it is possible to manufacture the substrate plate 1, that is used in the plasma display device shown according to Figure 1.

[0023]

Then, as another method, there is the method where the mixed material 21, that is filled into the molding die 20, is reaction cured or dried, and it is solidified, and after that, it is die released from the molding die, and the whole surface is treated for removing the binder material, and then this molded body is adhered onto the back surface plate 10. And then, finally, after that, the whole body is simultaneously annealed and unified as one body, and by that also, it is possible to manufacture the substrate plate 1, that is used in the plasma display device shown according to Figure 1.

[0024]

Or the mixed material 21, that is filled into the molding die 20, is reaction cured or dried, and it is solidified, and after that, it is die released from the molding die, and the whole surface is treated for removing the binder material, and then it was annealed and after that this annealed bonded body is adhered onto the back surface plate 10, and by thermal pressure adhesion or by simultaneous annealing it is bonded and by that also, it is possible to manufacture the substrate plate 1, that is used in the plasma display device shown according to Figure 1.

[0025]

Namely, the bonding of the molded body formed from the mixed material 21, onto the back surface plate 10, can be accomplished by any of the steps, the step where the parts are mutually non annealed molded materials, the step where they are in the state where the binder material has been removed, the step where it is an annealed bonded body.

[0026]

According to such manufacturing method of the present invention, the barrier 11 can be formed by one step, and because of that, the manufacturing technological process can be extremely simplified. And not only that, but also, in the case of the barriers 11, the shape of the indented part 20 a of the molding die 20, is copied, and because of that it is possible to form a fine shape with a high precision. And as a result from that, according to the manufacturing method of the present invention, at the time when the dimension of the cell part of the display cell 1000, is measured in 45 columns, the largest difference in the measured values, is 0.05 mm or less, and it is possible to obtain a high precision.

[0027]

Moreover, regarding the electrodes 12, that are provided on the bottom surface of the cells 13, it is also a good option if prior to the bonding of the barriers 11, in advance, they are provided on the front surface of the back surface plate 10.

[0028]

Here, as the ceramics powder material, that is used in order to form the barriers 11, it is possible to use any of the following materials: alumina ( $\text{Al}_2\text{O}_3$ ), zirconia ( $\text{ZrO}_2$ ), etc., oxide type ceramics, or silicon nitride ( $\text{Si}_3\text{N}_4$ ), aluminium nitride ( $\text{AlN}$ ), silicon carbide ( $\text{SiC}$ ) etc., non-oxide type ceramic materials, etc., or apatite ( $\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH})$ ) etc. And in these ceramics powder materials, it is also possible to add predetermined amounts of different types of sintering promoting agents.

[0029]

As the above described sintering promoting agents, in the alumina powder material, it is possible to add predetermined amounts of silica ( $\text{SiO}_2$ ), calcia ( $\text{CaO}$ ), yttria ( $\text{Y}_2\text{O}_3$ ) and magnesia ( $\text{MgO}$ ), etc., and into the zirconia powder material, it is possible to add the predetermined amounts of yttria ( $\text{Y}_2\text{O}_3$ ), or cerium ( $\text{Ce}$ ), dysprosium ( $\text{Dy}$ ), ytterbium ( $\text{Yb}$ ), etc., oxide of rare elements, and also, in the silicon nitride powder material, it is possible to add predetermined amounts of yttria ( $\text{Y}_2\text{O}_3$ ) and alumina ( $\text{Al}_2\text{O}_3$ ), etc., and in the aluminium nitride powder material, it is possible to add predetermined amounts of oxides of elements from the Group 3 a of the periodic table of Chemical Elements ( $\text{Re}_2\text{O}_3$ ), etc., and in the silicon carbide powder material, it is possible to add the predetermined amounts of boron ( $\text{B}$ ) and carbon ( $\text{C}$ ), etc.

[0030]

Also, as the glass powder material, that forms the barriers 11, it is possible to use different types of glass materials, containing as their main component silicate salts, and also containing one or more types of lead ( $\text{Pb}$ ), sulfur ( $\text{S}$ ), selenium ( $\text{Se}$ ), alum etc.

[0031]

Furthermore, regarding the grain size of these ceramics or glass powder materials, it is possible to appropriately use materials with a grain size from several tens of microns to submicrons, and in more details, it is a good option to use materials with a grain size that is in the range of 0.2 ~ 10 microns, and preferably, in the range of 0.2 ~ 5 microns.

[0032]

Then, as the organic additive materials, that are added to these ceramics or glass powder materials, urea resins, melamine resins, phenol resins, epoxy resins, unsaturated polyester resins, alkyd resins, urethane resins, ebonite etc., can be used. Then, as the means for the reaction curing of these organic additive materials,

thermal curing, ultraviolet light radiation curing, X ray radiation curing, etc., can be used. Moreover, from an operational point of view and equipment point of view, the thermal curing is the most preferred method. And especially, from the point of view of the "pot life", the unsaturated polyester resins are preferred. Regarding the contained amount of the above described organic additive materials, in order to maintain the flowability properties and the molding properties of the mixed material obtained from the ceramics or glass powder material and the sintering promoting agent, it is necessary that the viscosity is not increased, and on the other hand, it is desirable that at the time of the curing the mixed material has sufficient shape retention properties. And from these points of view, the contained amount of the organic additive materials, relative to 100 weight parts of the ceramics and glass powder material, is 0.5 weight parts or more, and also, from the point of view that it is said that there is shrinkage of the molded material upon curing, it is preferred that it is no more than 35 weight parts, or less, and among these amounts, if the shrinkage at the time of the sintering is considered, the amounts in the range of 1 ~ 15 weight parts, are most appropriate.

[0033]

Also, as the solvent media, that is added inside the mixed material 21, as long as it is a solvent agent that can dissolve the above described organic additive material, there are no specific limitations, and for example, it is possible to use toluene, xylene, benzene, phthalic acid ester, etc., aromatic solvent agents, hexanol, octanol, decanol, oxyalcohol, etc., high homologous order alcohol type organic solvents, or acetic acid esters, glycerides, etc.

[0034]

Especially, the above described phthalic acid esters, oxy alcohols, etc., can be appropriately used, and especially, in order that the solvent media is volatilized gradually, it is also possible that 2 types or more of the above described solvent agents are used together. And also, regarding the contained amount of the above described solvent media, from the point of view of the molding properties, in order to maintain the shape retention properties of the molded material, it is necessary that it is contained in an amount of at least 0.1 weight parts or more, relative to 100 weight parts of the ceramics and glass powder material. And on the other hand, it is desirable that the viscosity properties of the mixed material obtained from the ceramics and glass powder material and the organic additive material, are made to be low, and because of that, it is desirable that the contained amount is no more than 35 weight parts, or less, and when the shrinkage at the time of the drying and at the time of the sintering is considered, it is most preferable that, the amount contained is in the range of 1 ~ 15 weight parts.

[0035]

Moreover, regarding the molding die 20, according to the present invention, it is a good option if at the time when the organic additive materials are curing, there are other materials that are not harmful. And there are no specific limitations regarding these materials, and for example, it is possible to use metals and resins, or rubber etc., and if necessary, it is also a good option if, in order to increase the die release properties and to eliminate the wear, a surface treatment is conducted on the surface coating etc.

[0036]

Also, regarding the above described back surface plate 10, it can be a non-sintered green sheet or a sintered material, and there are no particular limitations regarding the material, and for example, different types of ceramic green sheets or different types of glass substrate plates, porcelain substrate plates, etc., are preferred, because they have a thermal expansion coefficient that is close to that of the material used in the barriers 11. Moreover, as the glass substrate plate, for example, soda lime glass, or a material where in order to improve the deformation point of that, an inorganic filler has been added and dispersed, etc., relatively inexpensive glass materials, can be used.

[[0037]

Also, in order to increase the adhesive properties at the time of the pressure adhesion of the above described mixed material 21 and the back surface plate 10, it is possible to use silane coupling agents, or titanate coupling agents, aluminate coupling agents, etc., different types of coupling agents, and among those, the silane coupling agents are preferred because of the fact that they increase the reactivity properties.

[0038]

Then, regarding the pressure adhesion of the mixed material 21 and the back surface plate 10, from the point of view that the pressure force is applied uniformly, it is desirable to use a hydrostatic pressure equipment, and as far as the elevated pressure conditions, they are within the range where there is no change of the shape of the molding die 20. And the above described pressure range varies depending on the strength of the molding die 20, however, for example, in the case when a molding die 20 manufactured from silicone rubber material, was used, it is preferred that the pressure adhesion is conducted under elevated pressure conditions of approximately 100 g/cm<sup>2</sup>.

[0039]

Also, in the mixed material 21, in order to increase the dispersibility properties of the ceramics or glass powder material, it is also a good option if a surface active

agent is added, like polyethylene glycol ether, alkyl sulfonic acid salts, salts of polycarboxylic acids, alkyl ammonium salts, etc. And as far as the contained amount of these, from the point of view of increasing the dispersibility properties and the thermal degradation properties, it is preferred that the content is in the range of 0.05 ~ 5 weight parts, relative to 100 weight parts of the ceramics or the glass powder material.

[0040]

Then, in the binder of the mixed material 21, it is possible to add a cure catalyst, that can be a cure reaction promoting agent or a polymerization initiation agent etc. And as the above described cure catalyst agent, it is possible to use organic peroxide compounds or azo compounds. For example, it is possible to use ketone peroxide, diazyl peroxide, peroxy ketal, peroxy ester, hydroperoxide, peroxy carbonate, t-butyl peroxy - 2- ethyl hexanoate, bis (4-t- butyl cyclohexyl) peroxy dicarbonate, dicumyl peroxide, etc., azo compounds. And moreover, in Figures 1 and 2, the trapezoid shape of the barriers 11 is shown, however the present invention is not limited to this example.

[0041]

#### [Practical Examples]

##### Practical Example 1

In order to evaluate the substrate plate, used in plasma display devices used according to the present invention, and its manufacturing method, as the ceramics powder materials the materials were used where alumina ( $Al_2O_3$ ), zirconia ( $ZrO_2$ ), silicon nitride ( $Si_3N_4$ ) and aluminium nitride ( $AlN$ ), that have an average particle diameter in the range of 0.2 ~ 5 microns, were correspondingly used as the main component, and the above described well known sintering promoting agents, were added and admixed depending on the needs. Relative to 100 weight parts of the above described ceramic powder materials, the binder compositions shown as No. 1 ~ 7, according to the presented here below Table 1, were correspondingly added and admixed, and this was mixed by stirring using a mixing equipment, and the viscosity was adjusted, and by that the mixed material 21, was manufactured. Moreover, the type of the shown in Table 1 binder composition materials, was according to each of the materials reported according to the presented here below Table 2.

[0042]

[Table 1]

試料 番号	セラミックス 粉体 主成分	バインダー組成						備考  13
		4 溶媒		有機性添加物 8		9 他の添加剤		
		種類 5	添加量 重量部 6	種類 7	添加量 重量部 10	種類 11	添加量 重量部 12	
1	①	①	10	②	15	分散剤	2	リン酸エステル - 15
2	"	②	"	①	"	—	—	
3	"	"	"	②	"	分散剤	2	リン酸エステル - 15
4	"	"	"	"	20	"	"	"
5	②	"	"	"	15	"	"	リン酸エステルポリグリコール - 16
6	③	"	15	"	"	—	—	
7	④	"	10	"	"	分散剤	2	リン酸エステルポリグリコール - 16
* 8	①	③	30	③	"	"	"	リン酸エステル、比較例

The experimental material numbers that have attached to them the \* symbol, are materials that are outside of the range of the claims of the present invention.

Headings in table 1:

1. Experimental material number, 2. main component of the ceramics powder material, 3. binder composition, 4. solvent media, 5. type, 6. added amount, weight parts, 7. type, 8. added amount, weight parts, 11. type, 12. added amount, weight parts, 13. remarks, 14. dispersing agent, 15. phosphoric acid ester, 16. dodecyl polyethylene glycol, 17. phosphoric acid ester, reference example.

[0043]

[Table 2]

	Number	Material name
Main component of the ceramics powder material	(1)	alumina
	(2)	zirconia
	(3)	silicon nitride
	(4)	aluminium nitride
Solvent media	(1)	phthalic acid diester
	(2)	octanol
	(3)	alpha-terpineol
Organic additive material	(1)	epoxy resin
	(2)	unsaturated polyester
	(3)	methyl cellulose

[0044]

The obtained by that mixed material 21 was defoamed by using a vacuum equipment, and after that, it was poured and filled through the main part by using a doctor blade, inside the indented part 20 a of the molding die 20, that has been prepared from silicone resin material. Regarding this indented part 20a, it has a reverse trapezoid shape, and the dimensions of the barrier 11 after the sintering were measured at the following: cell pitch dimension - 0.22 mm, width of the barrier 11 - 0.05 mm, dimension of the cell's top surface opening - 0.17 mm, dimension of the cell bottom surface - 0.05 mm, cell height is 0.10 mm. Moreover, regarding the above described defoaming treatment, it is also a good option if it is conducted after the mixed material 21 has been filled into the molding die 20.

[0045]

After that, on the front surface of the mixed material 21, that has been filled into the above described molding die 20, the back surface plate 10, that is formed from the same type of ceramic sintered material, as the mixed material 21, is mounted, and the above described flat plate together with the molding die 20, are inserted into a heating oven, etc., while applying an elevated pressure of 100 g/cm<sup>2</sup>, and at a temperature of 100°C, it is held for 45 minutes, and it is heat cured.

[0046]

After the completion of the curing, the back surface plate 10 and the adhered mixed material 21 molded body, are die released from the above described molding die 20, and the above described molded body is dried at a temperature of 120°C for a period of 5 hours, and after that, in a nitrogen ambient atmosphere, first, it is held at a temperature of 250°C for 3 hours and after that, the temperature is increased to 500°C and at this temperature, it is held for a period of 12 hours, and the binder is removed. After that, the material that has as its main component alumina, is held in air at a temperature of 1600°C for a period of 2 hours, and in the case of zirconia, it is held in air, at a temperature of 1450°C for a period of 2 hours, and in the case of silicon nitride it is held in a nitrogen atmosphere at a temperature of 1650°C for a period of 10 hours, and in the case of aluminium nitride, it is held in a nitrogen atmosphere at a temperature of 1800°C for a period of 3 hours,, and correspondingly, these are sintered and unified as one body, and the substrate plates 1 used in plasma display devices, according to the present invention, are obtained.

[0047]

On the other hand, as a reference example, into the ceramics powder material that has as its main component, the same alumina as in the above described, as shown according to No. 8 in table 1, methyl cellulose and alpha terpineol are added and

mixed and this was used as the paste used for the printing. And by using the thick layer printing method, a printing is repeated and the substrate plate 1, that is used in plasma display devices that have barriers 11, that are the same way as in the above described.

[0048]

By using the obtained according to that substrate plates 1, used in plasma display devices, according to the practical examples and the reference examples of the present invention, the front surface roughness of the barrier 11, was measured by using the contact type surface roughness meter (Surf Coater SE-2300). And also, regarding the precision of the dimensions of the barrier 11, the length in the space of 1000 cells was measured in 45 columns by using a micrometer, and it was evaluated by the maximum difference between the measured values. The results from that are shown in Table 3, presented here below.

[0049]

[Table 3]

1 試料 番号	2 表面粗さ R <sub>max</sub> μm	3 寸法精度 (mm)	4 表 示 セ ル 形 状	5 備 考
1	1.2	≤ 0.05	良 好	6
2	1.7	"	"	
3	1.3	"	"	
4	1.4	"	"	
5	1.7	"	"	
6	1.8	"	"	7
7	1.3	"	"	
*8	6.7	0.35	不 良	一部潰れ有り、比較例 8

The experimental material numbers that have the symbol \* attached to them, are materials that are outside the range of the claims of the present invention.

Headings in the table:

1. Experimental material number, 2. surface roughness, R<sub>max</sub> (μm), 3. dimensional

precision (mm), 4. display cell shape, 5. remarks, 6. good, 7. poor, 8. one part is destroyed, a reference example.

[0050]

From these results, it is confirmed that, in the case of the No. 8, that has a barrier 11, that has been formed according to the thick layer printing method, which is a reference example, the surface roughness of the barrier 11, is high at  $R_{max}$  of 6.7 microns, and the dimensional precision also is rough, as the maximum difference between the measured values is 0.35 mm, and also, in the display cell shape, one part has been destroyed.

[0051]

Contrary to that, in the case of No. 1 ~ 7, which are the practical examples according to the present invention, in all of them ceramics powder materials have been used, and despite that, the surface roughness of the barriers 11, was  $R_{max}$  1.8 microns and it was small, and also, the maximum difference between the measured values, was less than 0.05 mm, and the dimensional precision was also excellent, and there has not been destruction confirmed in the display cell shape.

[0052]

Moreover, the present invention is an invention that is not limited to the above described practical implementation examples, and even if as the main component of the ceramics powder material, apatite ( $Ca_5(PO_4)_3(F, Cl, OH)$ ) or glass ( $Na_2O \cdot CaO \cdot 5SiO_2$ ) etc., are used, it has been confirmed that the same results are obtained.

[0053]

Also, regarding the shape of the molding die 20 that is used in order to form the barrier 11, that forms the structure of the display cells according to the present invention, according to the above described practical example, an explanation has been provided by using an indented part 20 a where the cross sectional surface shape is a trapezoid shape, however, the shape of the molding die used according to the present invention is not limited to this type of shape.

[0054]

## Practical Example 2

After that, by using the mixed material 21 according to No. 1 and 6, among the above described practical examples according to the present invention, the same way as described according to the technological procedures of the Practical Example 1, a molding die is used, and the barrier 11, was formed, and it was bonded to the back

surface plate 10.

[0055]

At this time, the mixed material 21 that forms the barrier 11, is bonded in a nonsintered state or in a state after sintering, correspondingly, and also, as the back surface plate 10, a nonsintered ceramic plate, a sintered ceramic plate, and a glass plate, 3 types of plates, were used. And at the time when these were correspondingly, examined regarding the presence or absence of separation or cracks at the time when they were sintered and unified as one body, the results obtained were according to the presented in the Table 4 here below.

[0056]

From these results, it is seen that in the case when a mixed material 21, formed from a ceramic powder material, in a nonsintered state, is bonded to back surface plate, manufactured from glass, because the temperature at the time of the sintering becomes different, cracks are generated. And contrary to that, if the mixed material 21, that is formed from ceramic powder material, is sintered in advance, it is a material that is capable of being bonded and unified as one body with the back surface plate 10, that is manufactured from glass.

[0057]

[Table 4]

No	成形体	2 背面板の種類		
		未焼成セラミックス	焼成セラミックス	ガラス
6 1	未焼成	3 ◎	4 ○	5 x
7	焼成	◎	◎	◎
6 8	未焼成	◎	○	x
7	焼成	◎	◎	◎

Headings in Table 4:

1. molded body, 2. type of the back surface plate, 3. nonsintered ceramics, 4. sintered ceramics, 5. glass, 6. nonsintered, 7. sintered.

◎ : there are no separations or cracks

O : there is a negligible amount of cracks and separation that is generated  
 X : there is a generation of cracks and separation

[0058]

### Practical Example 3

As the mixed material 21, that forms the barrier 11, as it is shown according to Table 5, glass powder material, where the average particle diameter is in the range of 0.2 ~ 10 microns (preferably, it is in the range of 0.2 ~ 5 microns), and different types of solvent media, organic additive materials, and some dispersing agents, were added and slurries were prepared. These mixed materials 21, were filled into the indented part 20 a of the molding die 20, and that was defoamed.

[0059]

On this front surface, the manufactured from glass back surface plate 10, was placed, and pressure was applied, and it was dried, and after that, the mixed material 21, was solidified, and it confirmed that this was bonded to the back surface plate 10, and then the molding die 20 was die released. After that, the whole body was sintered at a temperature in the range of 500 ~ 700°C, and by that the substrate plate 1, that is used in plasma display devices, was obtained.

[0060]

[Table 5]

No	主成分	2 バインダー組成 (重量部)		
		3 溶媒	4 有機性添加物	5 他の添加物
1	ガラス 6	アクリル酸エステル 10	不飽和ポリエステル 9 15	分散剤 2
2	"	アクリル 8	エポキシ樹脂 10 15	—
3	"	" 10	不飽和ポリエステル 11 15	分散剤 2
4	"	" 10	" 20	分散剤 2
5	"	" 15	" 15	—
6	"	α-トルエン 30	アクリル酸 12 15	分散剤 2

Headings in Table 5:

1. main component, 2. binder composition (weight parts), 3. solvent media, 4. organic additive material, 5. other additives, 6. glass, 7. diester of the phthalic acid, 8. octanol, 9. unsaturated polyester, 10. epoxy resin, 11. unsaturated polyester, 12. methyl cellulose, 13. dispersing agent 2, 14. alpha - terpineol.

[0061]

On the other hand, as a reference example, according to the printing method used in the previous technology, in order to form the barrier 11 on the manufactured from glass, back surface plate 10, screen printing and drying were repeated 10 times, and after that, this was sintered at a temperature in the range of 500 ~ 700°C, and by that the substrate plate 1, used in plasma display devices, was produced (No. 7).

[0062]

For the obtained according to the above described No. 1 ~ 7, experimental materials, the shape of the barrier 11, and the presence or absence of cracks were observed by using a binocular microscope, and the results from that are shown according to the presented in Table 6.

[0063]

According to these results, in the case of the No. 7, which is the reference example, the shape of the barrier 11, was not defined. And contrary to that, in the case of the practical examples according to the present invention (No. 1 ~ 6), except for the case of No. 6, where the amount of the solvent medium was high, and because of that, some destruction of the barrier 11, was generated, generally, the shape of the barrier 11, was good, and also there was no generation of cracks. Consequently, even in the case when in the back surface plate 10 or in the barrier 11, glass was used, it was understood that it was also possible to well manufactured a substrate plate 1, that is used in plasma display devices.

[0064]

[Table 6]

No.	1 隔壁の形状	2 クラック の有無	3 隔壁と電極 の位置ずれ
1	良好 4	無し 5	無し
2	"	無し	無し
3	"	無し	無し 5
4	"	無し	無し
5	"	無し	無し
6	一部潰れあり 8	一部有り 6	無し
* 7	形状が不明確 9	無し 5	ずれ有り 7

\* denotes a reference example.

Headings in the table:

1. shape of the barrier, 2. presence or absence of cracks, 3. positional difference between the barrier and the electrodes, 4. good, 5. no, 6. there is on one part, 7. there is a deviation, 8. there is a partial destruction, 9. the shape is undefined.

[0065]

#### [Results from the present invention]

As it is clear from the above described, in the case of the substrate plate used in plasma display devices and its manufacturing method, according to the present invention, it is possible to suggest a substrate plate used in plasma display devices and its manufacturing method, where a mixed material obtained from ceramics or glass powder material and binder is filled inside a molding die, and the obtained by that molded body and a back surface plate, that is formed from ceramics or from glass, are bonded and formed as unified body. And because of that, it is possible to manufacture that plate by a one time molding technological process. And also, regarding the dimensional precision of the molding die, because it is copied onto the molded body in the state as it is, barriers with a good surface roughness are obtained, and a large form factor can be easily obtained in practice. As a result from that, it is possible to shorten and simplify the manufacturing technological processes, and to realize in practice a high manufactured product yield rate, and a high degree of accuracy.

#### [Simple explanation of the figures]

[Figure 1]

Figure 1 is an oblique angle diagram where one part is taken out, of the substrate plate used in plasma display devices.

[Figure 2]

Figure 2 (a) and (b) represent diagrams in order to explain the manufacturing method for the preparation of the substrate plate used in plasma display devices

according to the present invention.

[Figure 3]

Figure 3 is a cross sectional view diagram showing a substrate plate used in plasma display devices according to the previous technology.

[Explanation of the symbols]

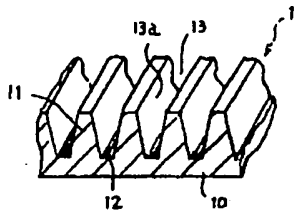
1.....substrate plate, 10.....back surface plate, 11.....barriers,  
12.....electrodes, 13.....cells, 14.....electrodes, 15.....front surface plate,  
20.....molding die, 21.....mixed material.

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*Translated by Albena Blagev (735-1461 (h), 704-7946 (w))*

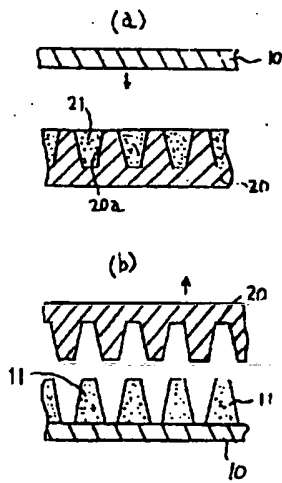
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[Figure 1]



【図 2】

[Figure 2]



【図 3】

[Figure 3]

